Building resilience into the legs

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NSCA®
NATIONAL STRENGTH AND CONDITIONING ASSOCIATION

2021 NSCA TACTICAL ANNUAL TRAINING

#NSCATactical21

CONFLICT OF INTEREST STATEMENT

I have no actual or potential conflict of interest in relation to this presentation.

Contents

- Injuries
- Lower limb fitness
- Understanding the Anatomy…Physiology…Biomechanics
- Summation and application

Learning Outcomes

- Recognize anatomical, biomechanical, and physiological influences imparted by lower limb structures and their impacts on performance and injury risk.
- Produce an evidence-based strength and conditioning program for different tactical populations to increase neuromuscular resilience for the lower limbs

Contents


Injuries
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Understanding the Anatomy, Physiology & Biomechanics
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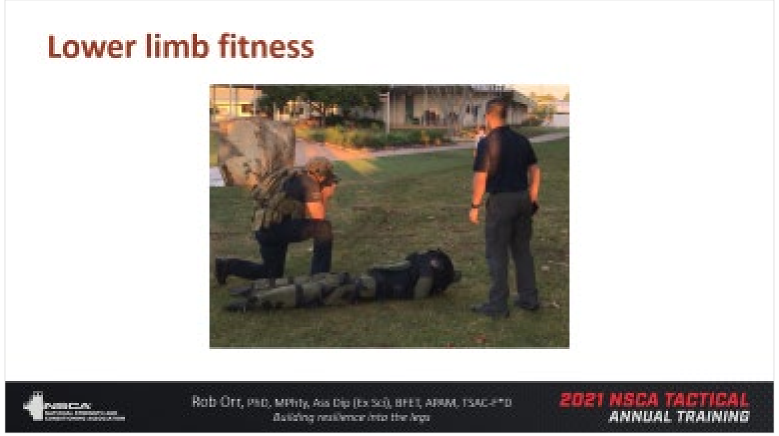
Lower limb fitness
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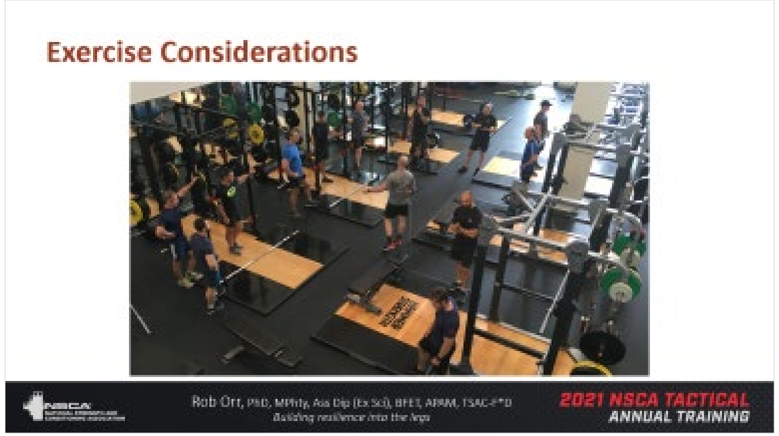
Exercise Considerations
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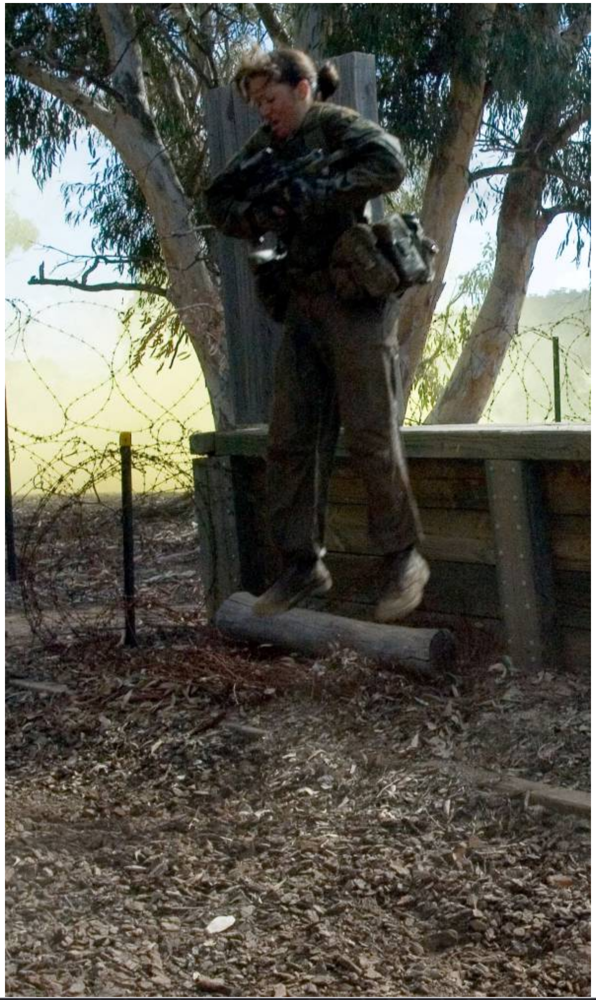
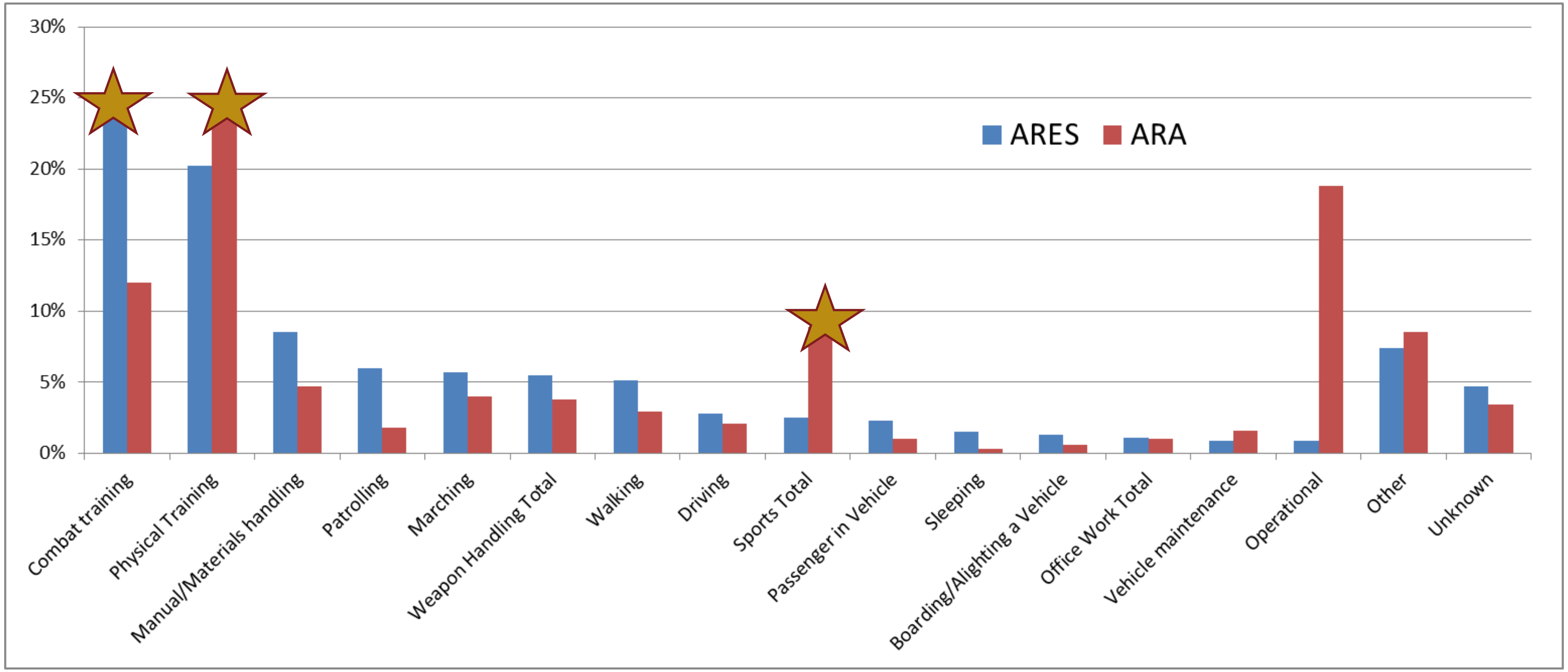
Injuries



Injuries

- Australian Army Injuries *(McDonald, et al., 2016)*



Injuries

- Australian Army Injuries *(Orr, et al., 2020)*

  Injured sites

    Ankle, n=212, 21.90%; and

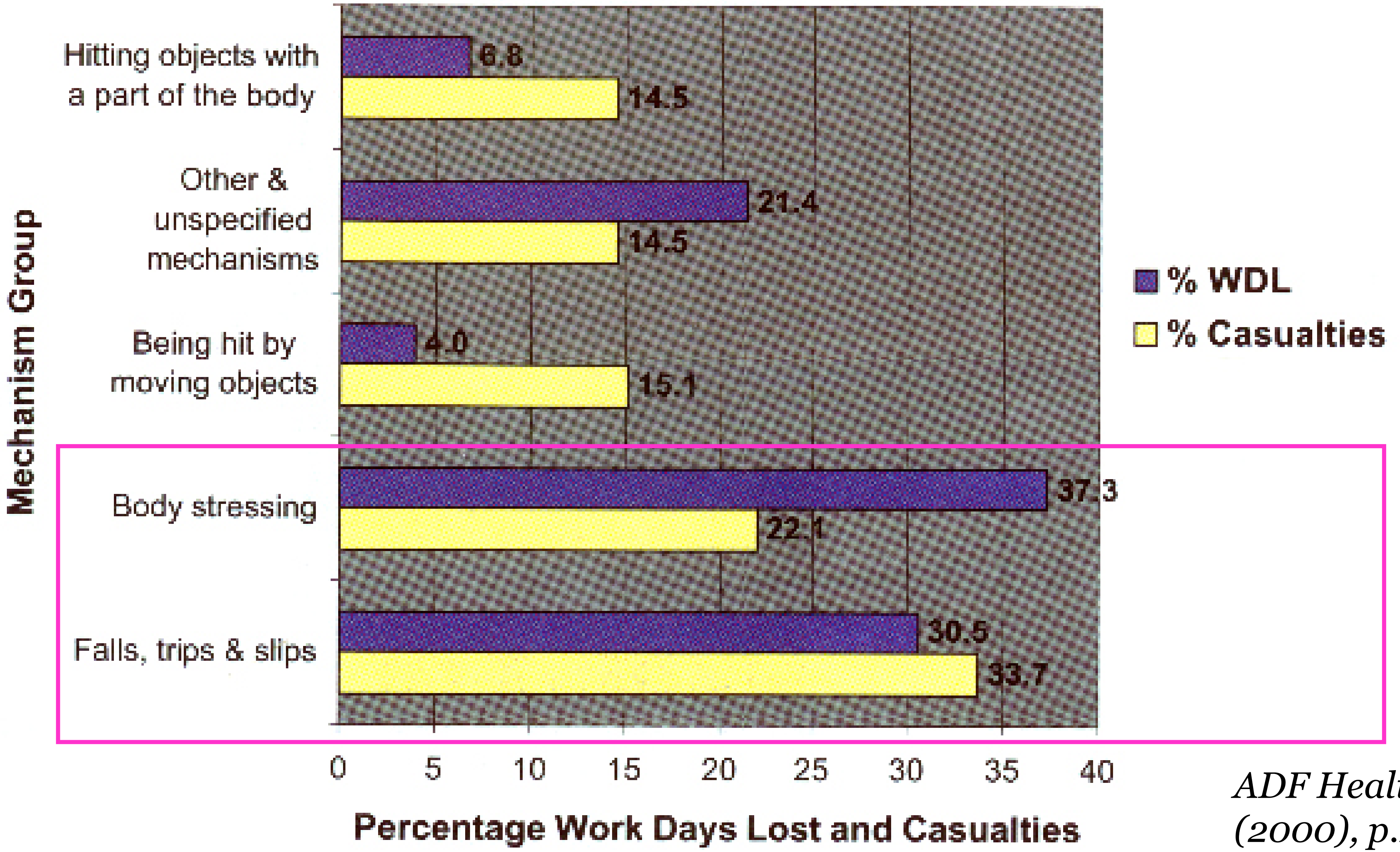
    Knee, n=166, 17.15%.

  Nature of injury

    Soft tissue injury, n=533, 55.06%;

    Dislocation, n=123, 12.71%; and

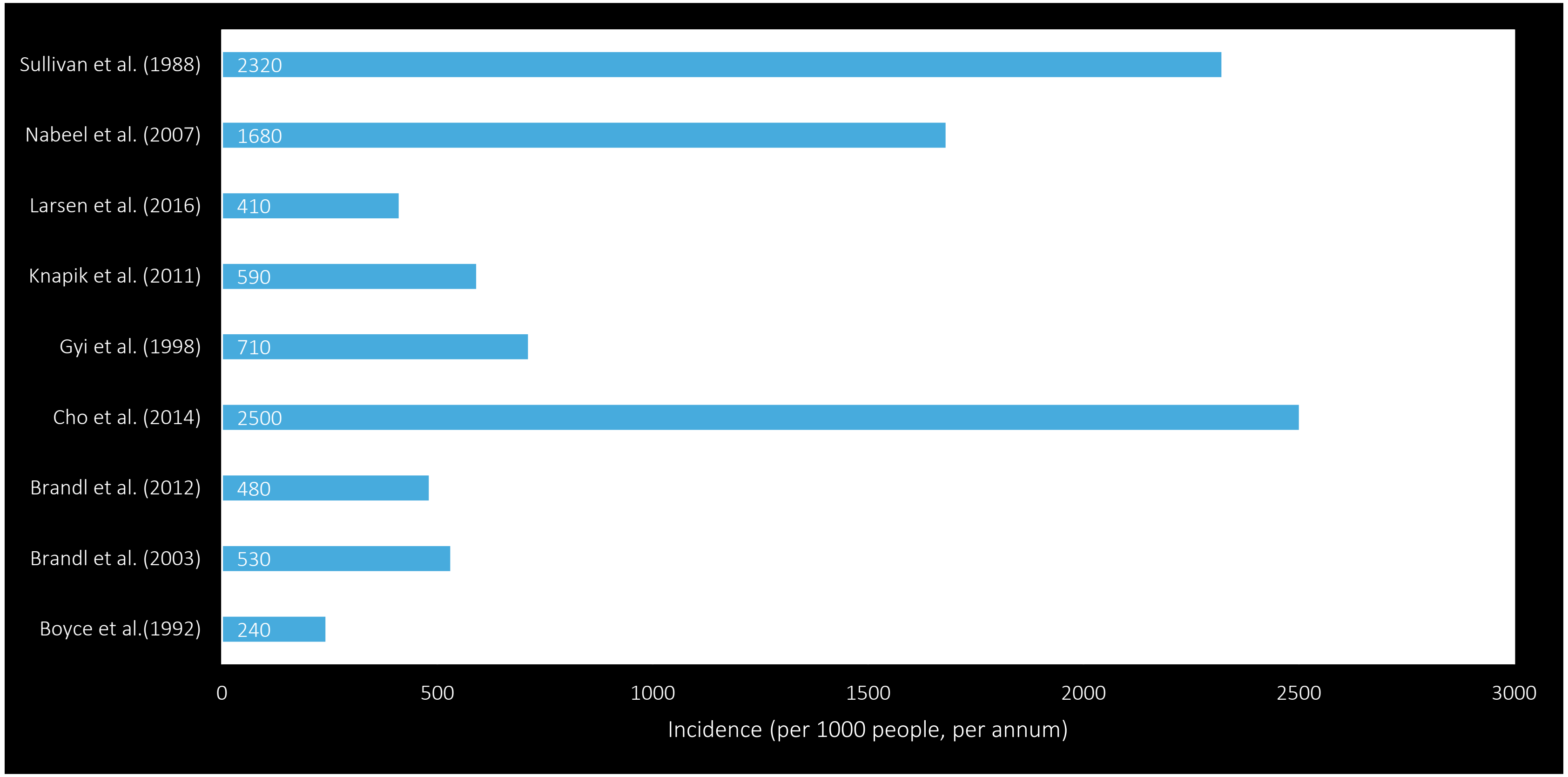
    Fractures, n=115, 11.88%

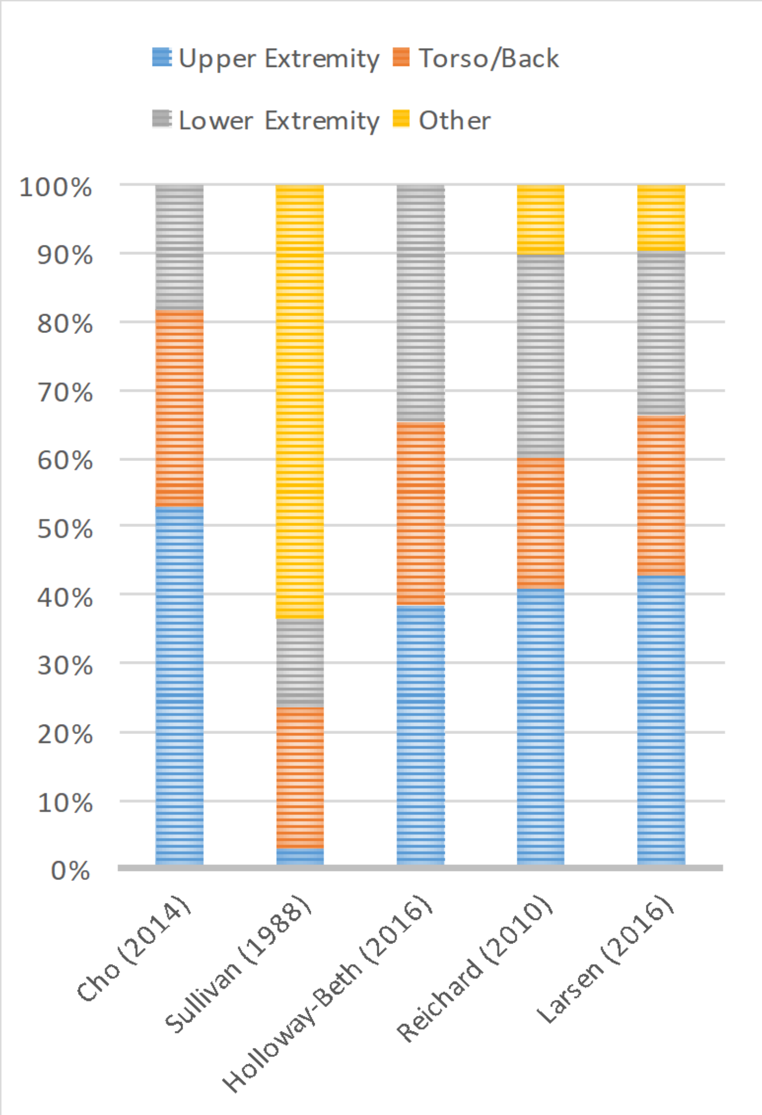


ADF Health Status Report (2000), p.1-27

Injuries

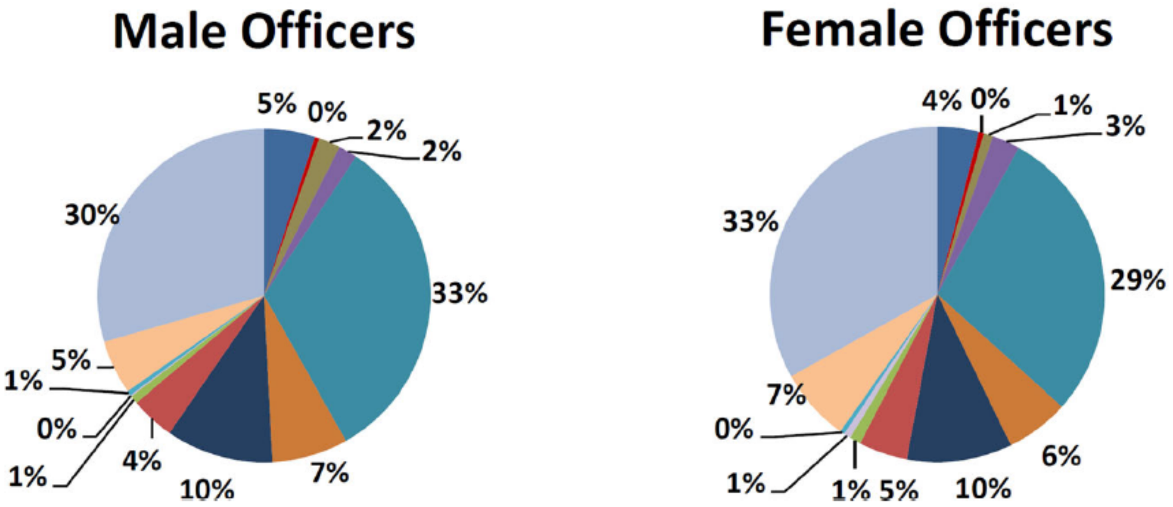
- Law Enforcement Injuries *(Lyons, et al., 2017)*





Injuries

- Law Enforcement Injuries to the lower limbs *(Lyons, et al., 2021)*
  - Overall MSK lower extremity incidence rates were 10.8 injuries per 100 personnel/year overall;
    - 10.8 injuries per 100 personnel/year for male LEO, and
    - 11.0 injuries per 100 personnel/year for female LEO



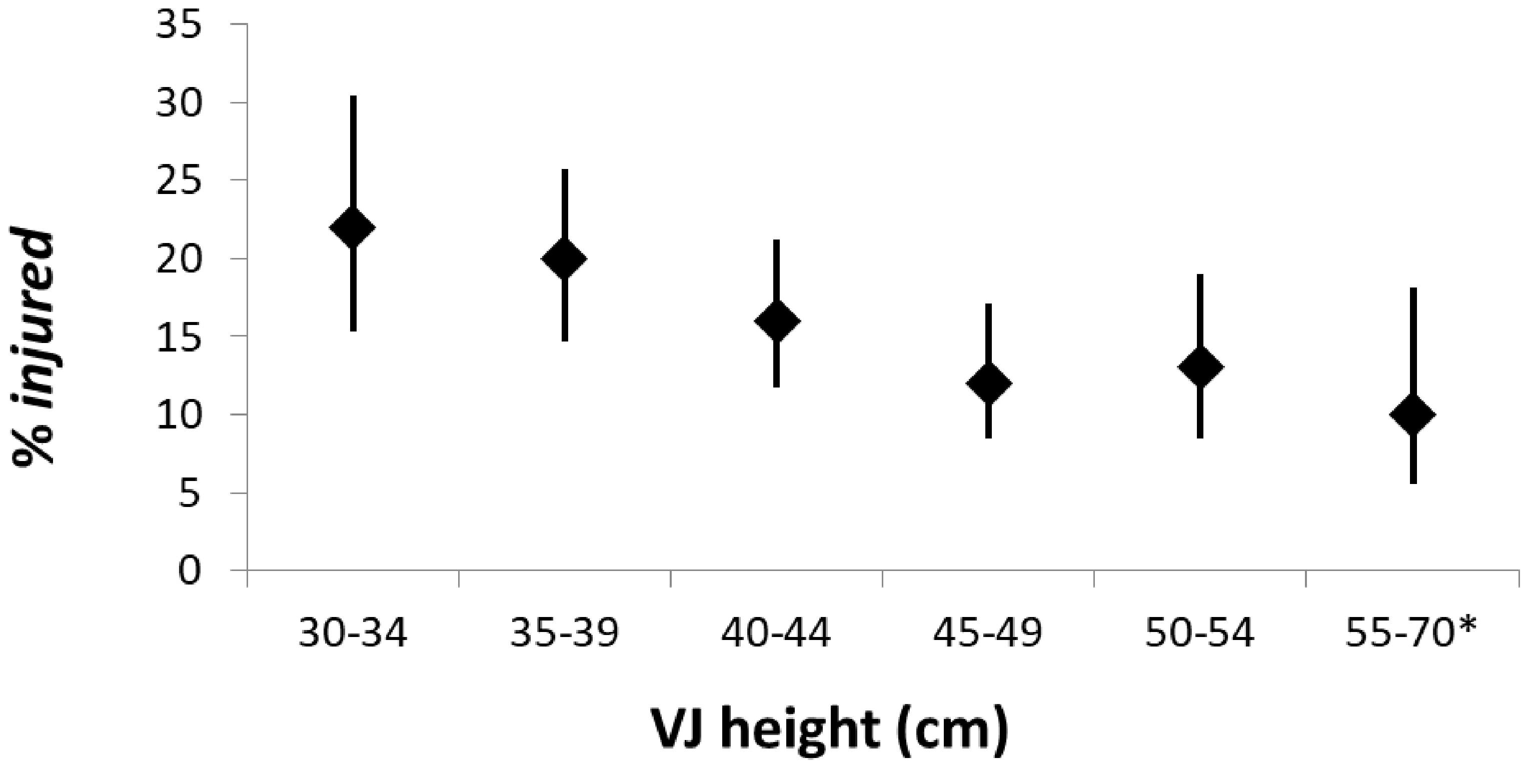
Injuries

- Firefighter Injuries *(Orr, et al., 2019a)*
  - MSK typically leading nature of injury, prevalence lower than law enforcement and military
  - Leading sites are back and lower extremity (knee a leading site)
  - Primary mechanism in wildland firefighters is slips, trips and falls while in structure, bending lifting and muscle stressing precede slips, trips and falls

Lower limb fitness

Lower limb fitness

- Police Recruits *(Orr, et al., 2016)*



Lower limb fitness

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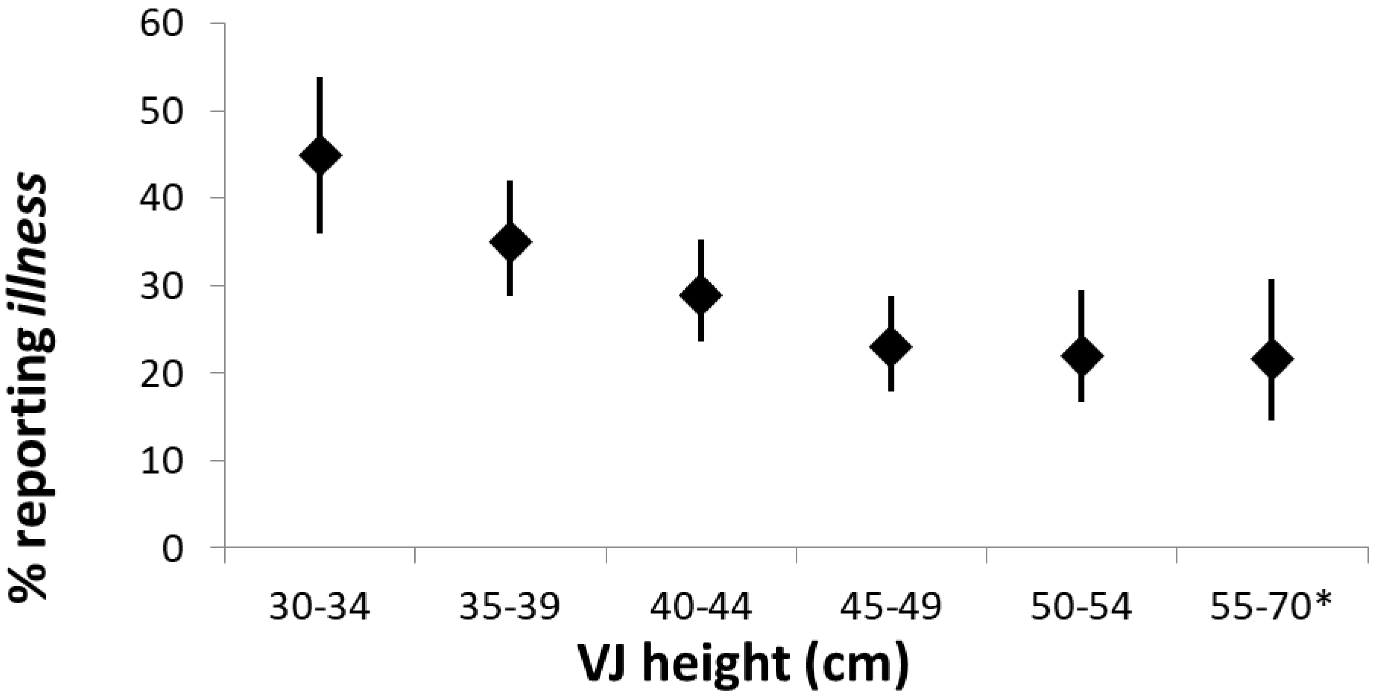
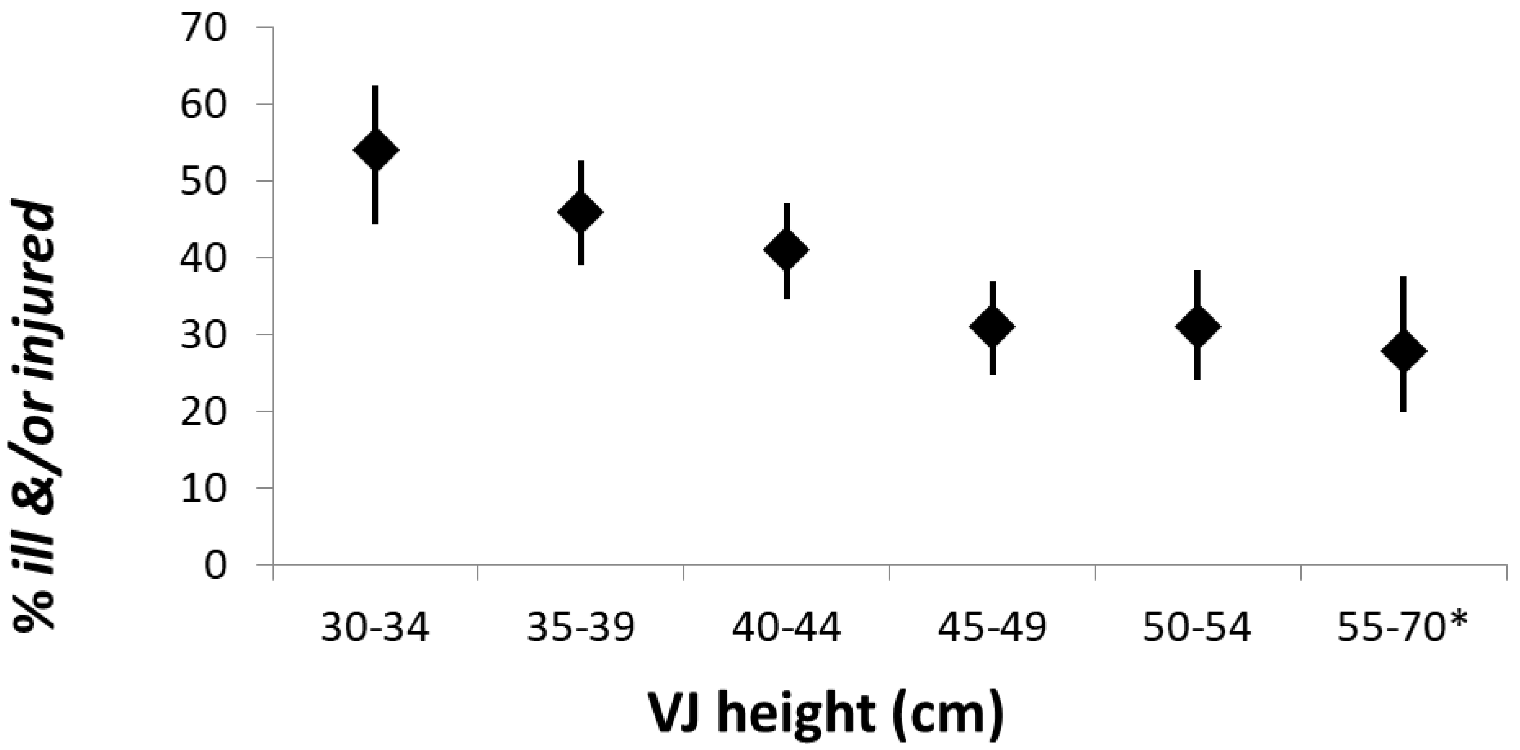


Lower limb fitness

- Police Recruits *(Orr, et al., 2016)*



Lower limb fitness

- SWAT Fitness *(Orr, et al., 2018)*

GROUPS	Group 1 (failed BFA)	Group 2 (passed BFA, failed to complete SSC)	Group 3 (completed SSC - not selected)	Group 4 (completed SSC - selected)	Correlation between characteristic & level of success
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	r_s, p
Pull Ups (reps)	12.63 ± 3.89	15.75 ± 6.14	14.57 ± 1.90	16.10 ± 3.38	0.41, p=.017*
Push Ups (reps)	46.00 ± 9.15	50.38 ± 9.37	47.57 ± 3.26	58.80 ± 11.89	0.45, p=.009**
Ab Str (Level 1-7)	2.63 ± 0.74	3.00 ± 0.00	3.00 ± 0.00	3.00 ± 0.00	0.35, p=.049*
March (secs)	4935.00 ± 770	4763.00 ± 176	4990.29 ± 300	4659.40 ± 233	-0.33, p=.078
MSFT (no. of shuttles)	95.00 ± 0.00#	102.88 ± 12.11	101.00 ± 12.72	101.60 ± 6.11	0.11, p=.585
Agility run (secs)	22.40 ± 0.00#	17.93 ± 1.08	17.08 ± 1.43	17.12 ± 0.53	-0.40, p=.043*
Lift and carry (secs)	173.00 ± 0.00#	174.00 ± 15.68	178.00 ± 8.76	160.60 ± 9.85	-0.49, p=0.010*

Lower limb fitness

- Police Recruits *(Lockie, et al., 2021)*

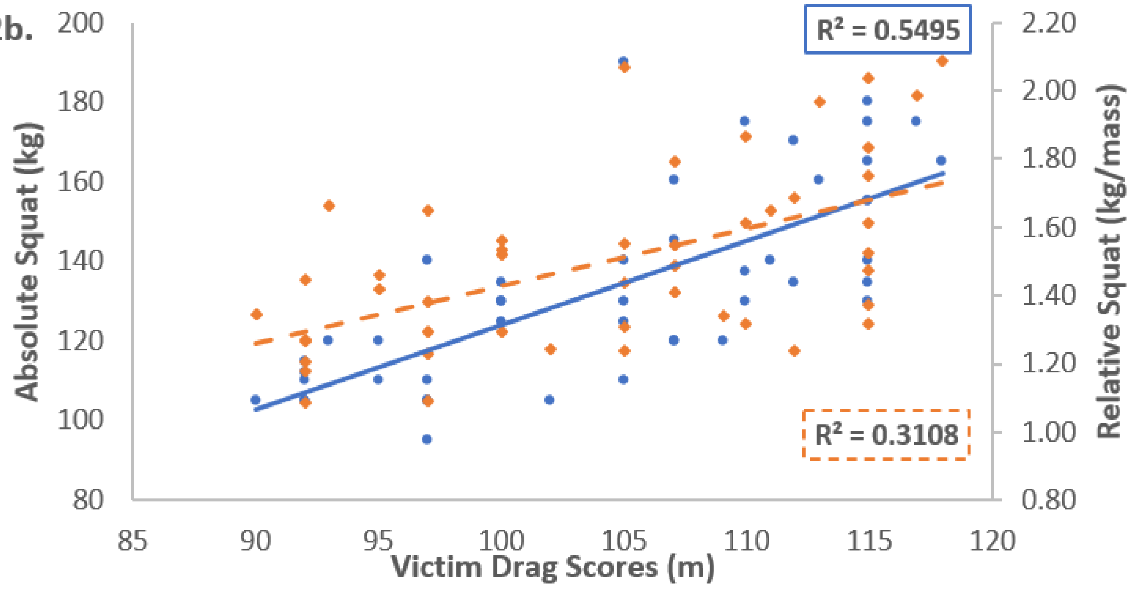
		99OC	BD	CLF	SW	500R
VJ	*r*	–0.35*	–0.09	–0.25*	–0.25*	–0.21*
	p	<0.01	0.16	<0.01	<0.01	<0.01
75PR	*r*	0.53*	0.11*	0.35*	0.21*	–0.29*
	p	<0.01	0.05	<0.01	<0.01	<0.01
MBT	*r*	–0.26*	–0.10	–0.20*	–0.07	–0.04
	p	<0.01	0.10	<0.01	0.25	0.49
MSFT	*r*	–0.27*	–0.09	–0.13*	–0.13*	–0.438*
	p	<0.01	0.13	0.02	0.02	<0.01

*Significant ($p < 0.05$) relationship between the two variables.

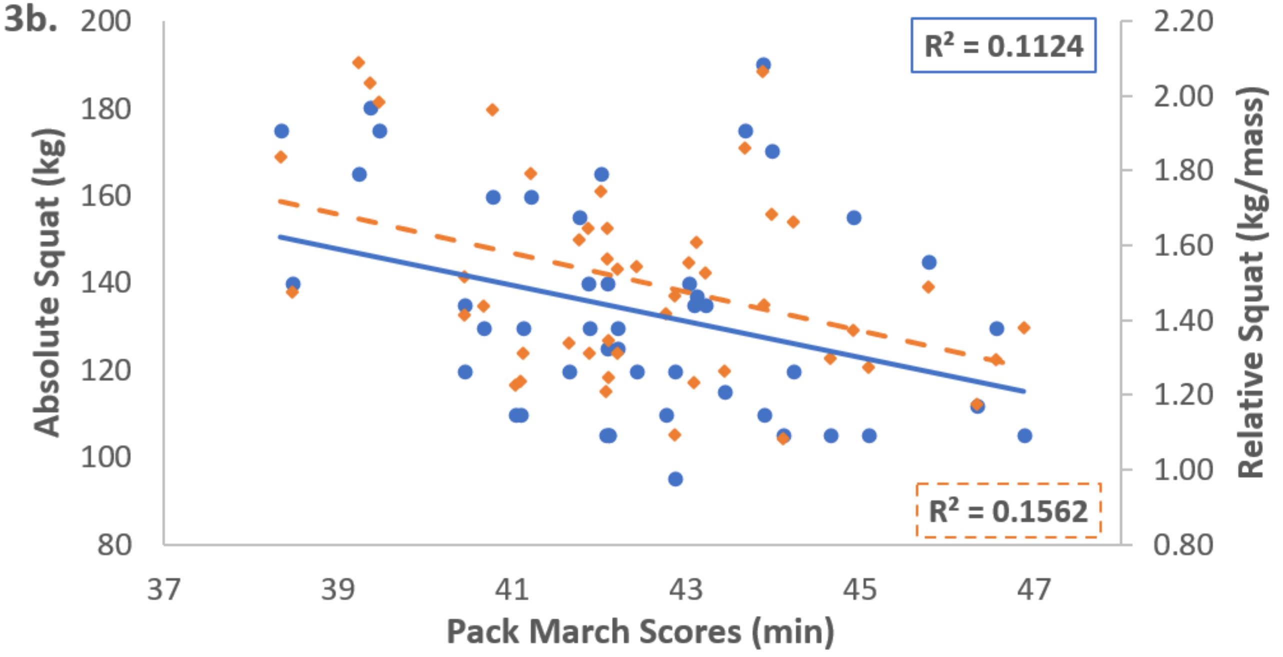
Lower limb fitness

- SWAT Fitness and task performance *(Orr, et al., 2020)*

2b.



3b.



Lower limb fitness

- SWAT Fitness *(Robinson, et al., 2018)*

Measure	Pack March 1 (mins:sec)	Pack March 2 (mins:sec)	Pack March 3 (mins:sec)
1RM Squat (kg)	-.401**	-.335*	-.316*
Squat Ratio (%)	-.500**	-.381**	-.396**
1RM Deadlift (kg)	-.288*	-0.248	-0.215
Deadlift Ratio (%)	-.403**	-.294*	-.305*
Vertical Jump (cm)	-.501**	-.541**	-.523**

** Correlation is significant at the 0.01 level (2-tailed).

Understanding the Anatomy, Physiology & Biomechanics

Understanding the Anatomy

- What is the purpose of this stretch?

Understanding the Anatomy

JAOA ORIGINAL CONTRIBUTION

Three-Dimensional Mathematical Model for Deformation of Human Fasciae in Manual Therapy

Hans Chaudhry, PhD; Robert Schleip, MA; Zhiming Ji, PhD; Bruce Bukiet, PhD; Miriam Maney, MS; and Thomas Findley, MD, PhD

Context: Although mathematical models have been developed for the bony movement occurring during chiropractic manipulation, such models are not available for soft tissue motion.

Objective: To develop a three-dimensional mathematical model for exploring the relationship between mechanical forces and deformation of human fasciae in manual therapy using a finite deformation theory.

Methods: The predicted stresses required to produce plastic deformation were evaluated for a volunteer subject's fascia lata, plantar fascia, and superficial nasal fascia. These stresses were then compared with previous experimental findings for plastic deformation in dense connective tissues. Using the three-dimensional mathematical model, the authors determined the changing amounts of compression and shear produced in fascial tissue during 20 seconds of manual therapy.

Results: The three-dimensional model's equations revealed that very large forces, outside the normal physiologic range, are required to produce even 1% compression and 1% shear in fascia lata and plantar fascia. Such large forces are not required to produce substantial compression and shear in superficial nasal fascia, however.

Conclusion: The palpable sensations of tissue release that are often reported by osteopathic physicians and other manual therapists cannot be due to deformations produced in the firm tissues of plantar fascia and fascia lata. However, palpable tissue release could result from deformation in softer tissues, such as superficial nasal fascia.

J Am Osteopath Assoc. 2008;108:379-390

From the departments of Biomedical Engineering (Drs Chaudhry and Findley), Mechanical Engineering (Dr Ji), and Mathematical Sciences (Dr Bukiet) at the New Jersey Institute of Technology in Newark; the Department of Applied Physiology at Ulm University in Germany (Mr Schleip); and the War-Related Illness and Injury Study Center at the Veterans Affairs Medical Center in East Orange, NJ (Drs Chaudhry and Findley, Ms Maney).

This study was partially supported by a dissertation grant from the International Society of Biomechanics to Mr Schleip's Fascia Research Project.

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Submitted March 23, 2006; revision received June 20, 2006; accepted August 10, 2006.

Fascia is dense fibrous connective tissue that connects muscles, bones, and organs, forming a continuous network of tissue throughout the body. It plays an important role in transmitting mechanical forces during changes in human posture. Several forms of manual fascial therapies—including myofascial release and certain other techniques in osteopathic manipulative treatment (OMT)—have been developed to improve postural alignment and other expressions of musculoskeletal dynamics.[1,2] The purpose of these therapies and treatments is to alter the mechanical properties of fascia, such as density, stiffness, and viscosity, so that the fascia can more readily adapt to physical stresses.[3,4] In fact, some osteopathic physicians and manual therapists report local tissue release after the application of a slow manual force to tight fascial areas.[2,4,5] These reports have been explained as a breaking of fascial cross-links, a transition from gel to sol state in the extracellular matrix, and other passive viscoelastic changes of fasciae.[2,4,5]

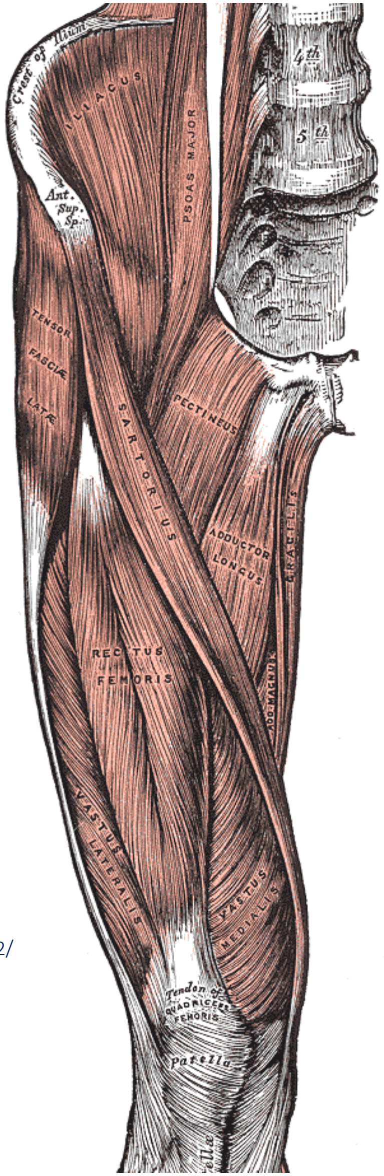
The question of whether the applied force and duration of a given manual technique (eg, myofascial) could be sufficient to induce palpable viscoelastic changes in human fasciae is unresolved, with some authors[1,5,6] supporting the likelihood of such an effect and others[7,8] arguing against it.

Our intent in undertaking the present study was to resolve this question. Therefore, we present an original mathematical model to determine if forces applied in manual therapy are sufficient to produce tissue deformation in human fasciae.

Background

The mechanical properties of ex vivo rat superficial fascia (ie, subcutaneous tissue) under uniaxial tension have been reported by Iatridis et al,[9] who investigated the potential importance of uniaxial tension in a variety of therapies involving mechanical stretch. The mechanical properties of in vitro human superficial nasal fascia and nasal periosteum were investigated by Zeng et al[10] to determine under which tissue layer silicon implants should be inserted for improved results in aesthetic surgical corrections of congenital saddle nose and flat nose. Similarly, the mechanical properties of in vitro fascia lata and plantar fascia have been investigated by Wright and Rennels.[11] The results of each of these studies of fascial mechanical properties can be used in determining the types and strengths of mechanical forces needed to produce desired deformations during manual therapy.

https://anytimeyoga.files.wordpress.com/2012/09/gray430.png



Understanding the Anatomy

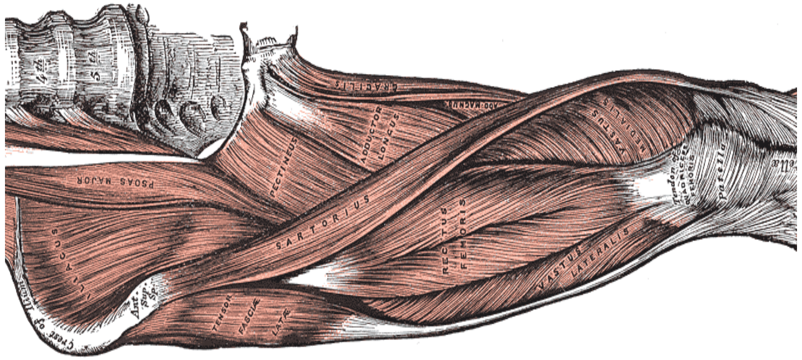
- What is the purpose of this exercise?

http://static1.squarespace.com/static/551035e3e4b0961711e870fe/t/551c230be4b0e383d17282e7/1427907340268/foam-roll.jpg?format=1500w

Understanding the Anatomy

- Are we effecting the ITB?
- So why do it?

http://static1.squarespace.com/static/551035e3e4b0961711e870fe/t/551c230be4b0e383d17282e7/1427907340268/foam-roll.jpg?format=1500w

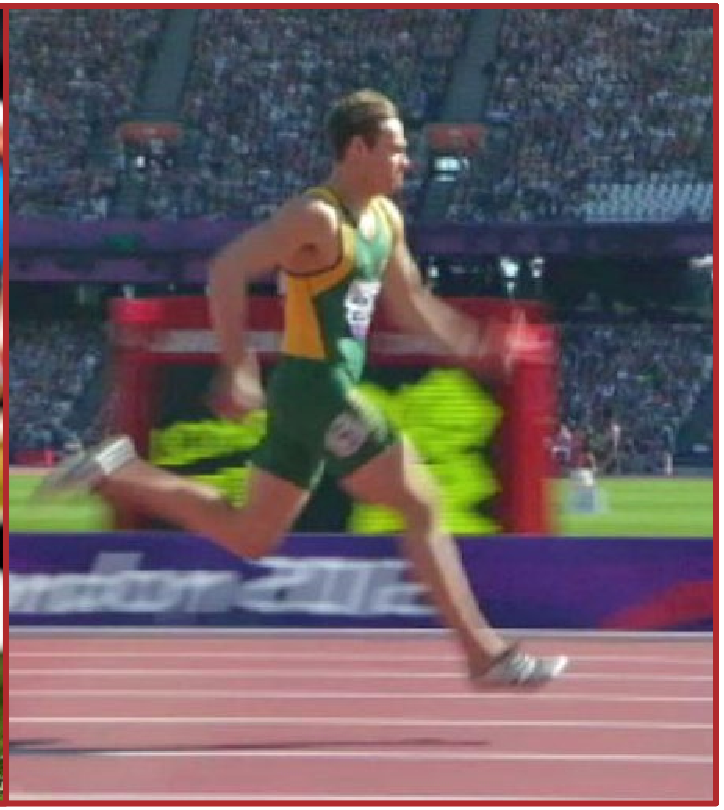


https://anytimeyoga.files.wordpress.com/2012/09/gray430.png

Understanding the Anatomy

- What exercises can you use to condition / recondition the hamstring?
- What Ranges of Motion do these exercises move the hamstring through?

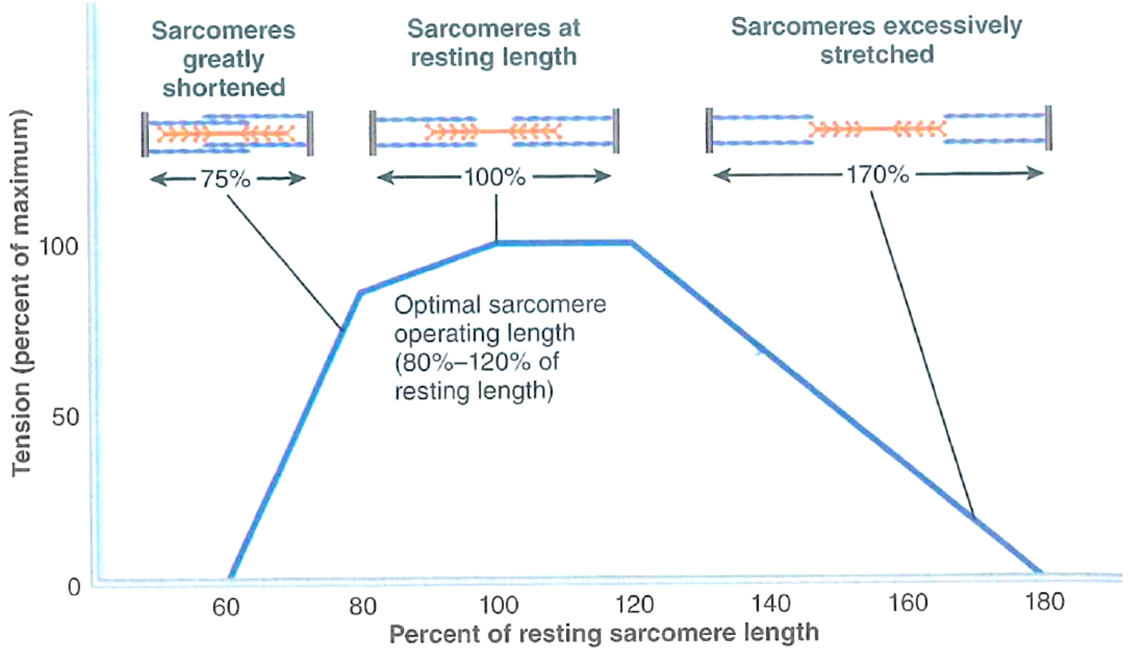
https://www.abc.net.au/news/2019-03-21/tayla-harris-trolls-arent-only-problem/10921784



http://www.abc.net.au/news/image/4250952-3x2-940x627.jpg

Understanding the Physiology

- The Length-Tension Curve
  - A muscle's sarcomeres will develop most tension at between 90-110* of resting length.



Marieb, E. N., & Hoehn, K. (2019). Human anatomy & physiology. 11th Edition Pearson education, fig 9.19, pg. 339

Understanding the Physiology

- The Length-Tension Curve
    - It impacts on muscles worked

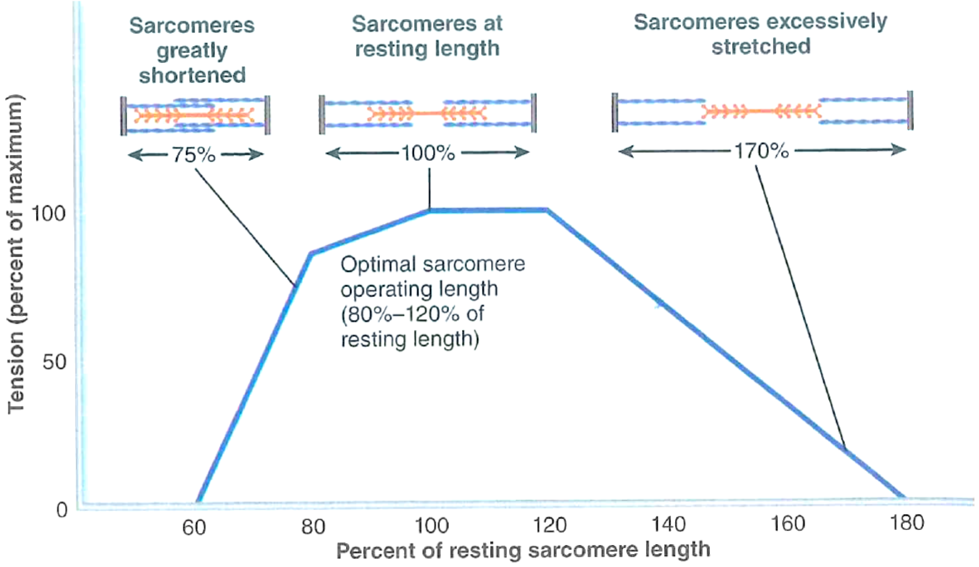
http://www.bodybuilding.com/fun/2002/seatedcalfraise1.jpg

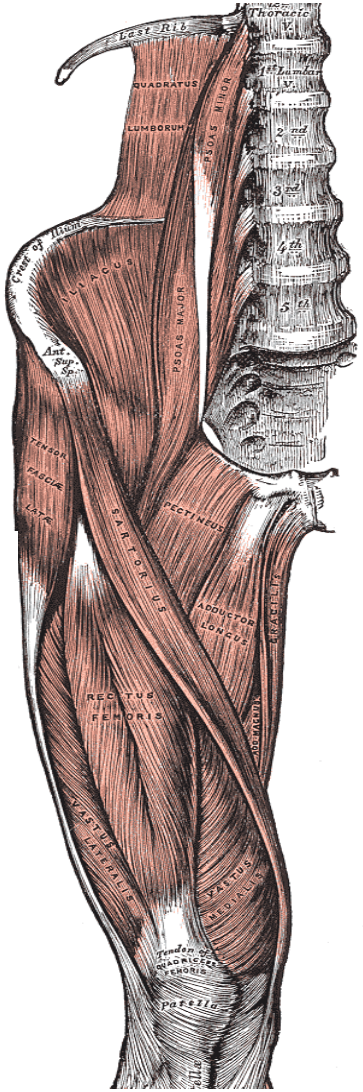
https://www.bodybuilding.com/content/leg-curls-done-light.html

Understanding the Physiology

- Where is the muscle belly of the hamstrings?
- Which muscles are at optimal length?

Understanding the Physiology





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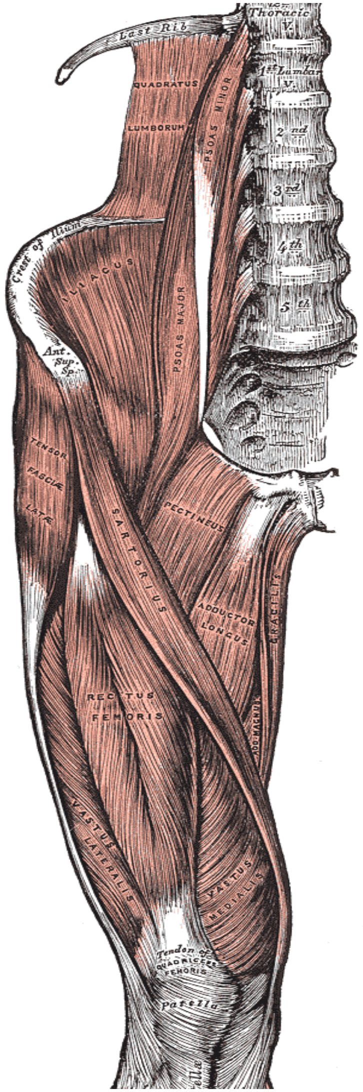
Understanding the Physiology

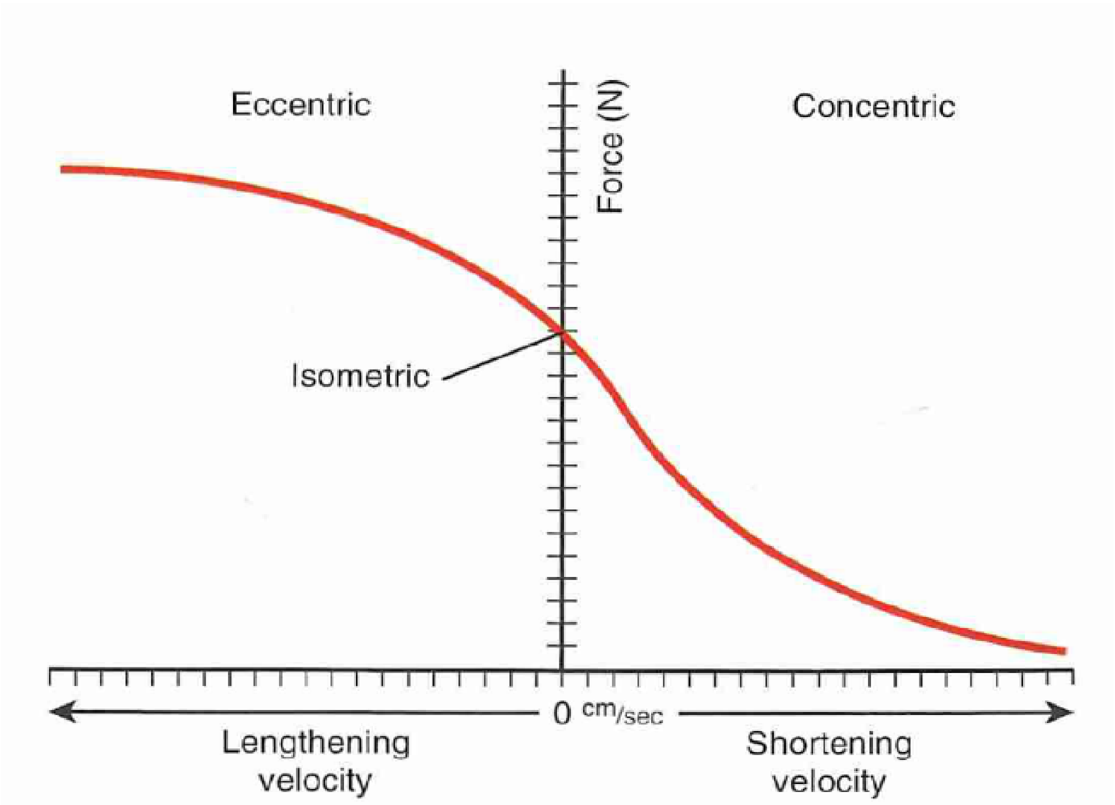
- An effective stretch?



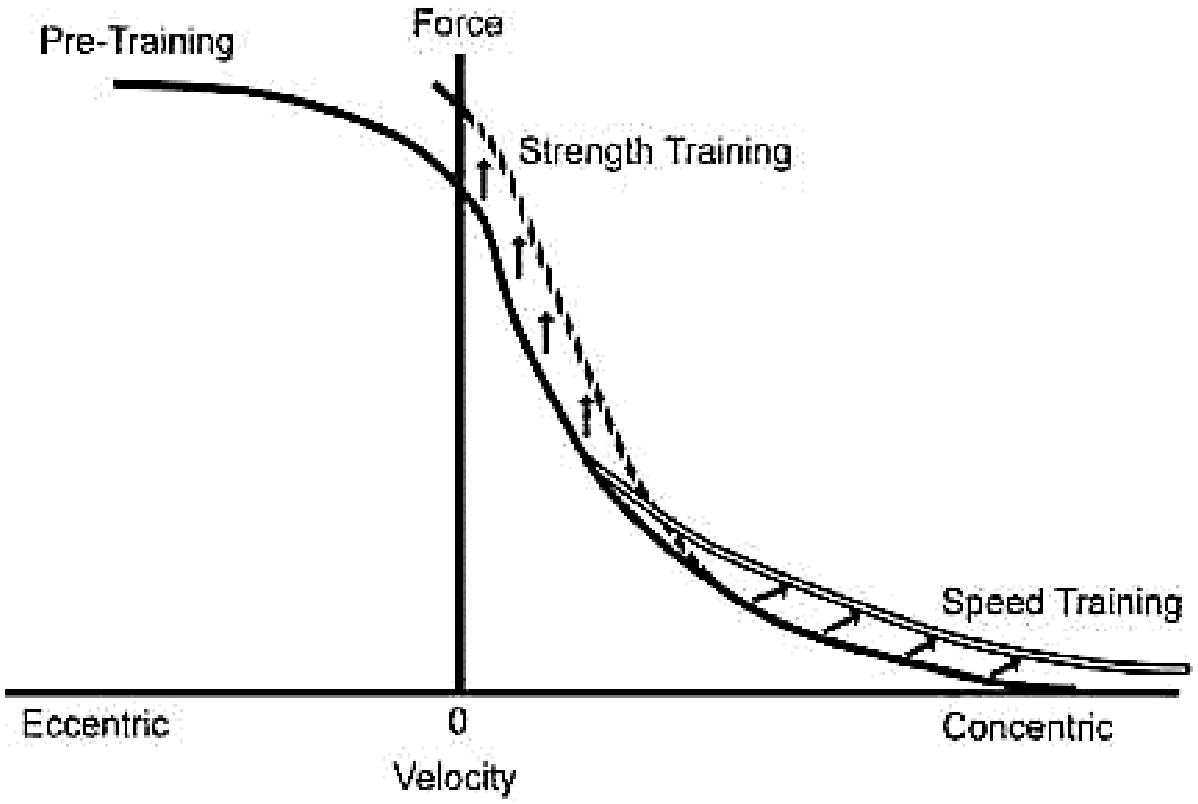
https://anytimeyoga.files.wordpress.com/2012/09/gray430.png

Understanding the Physiology

- The Force-Velocity Curve



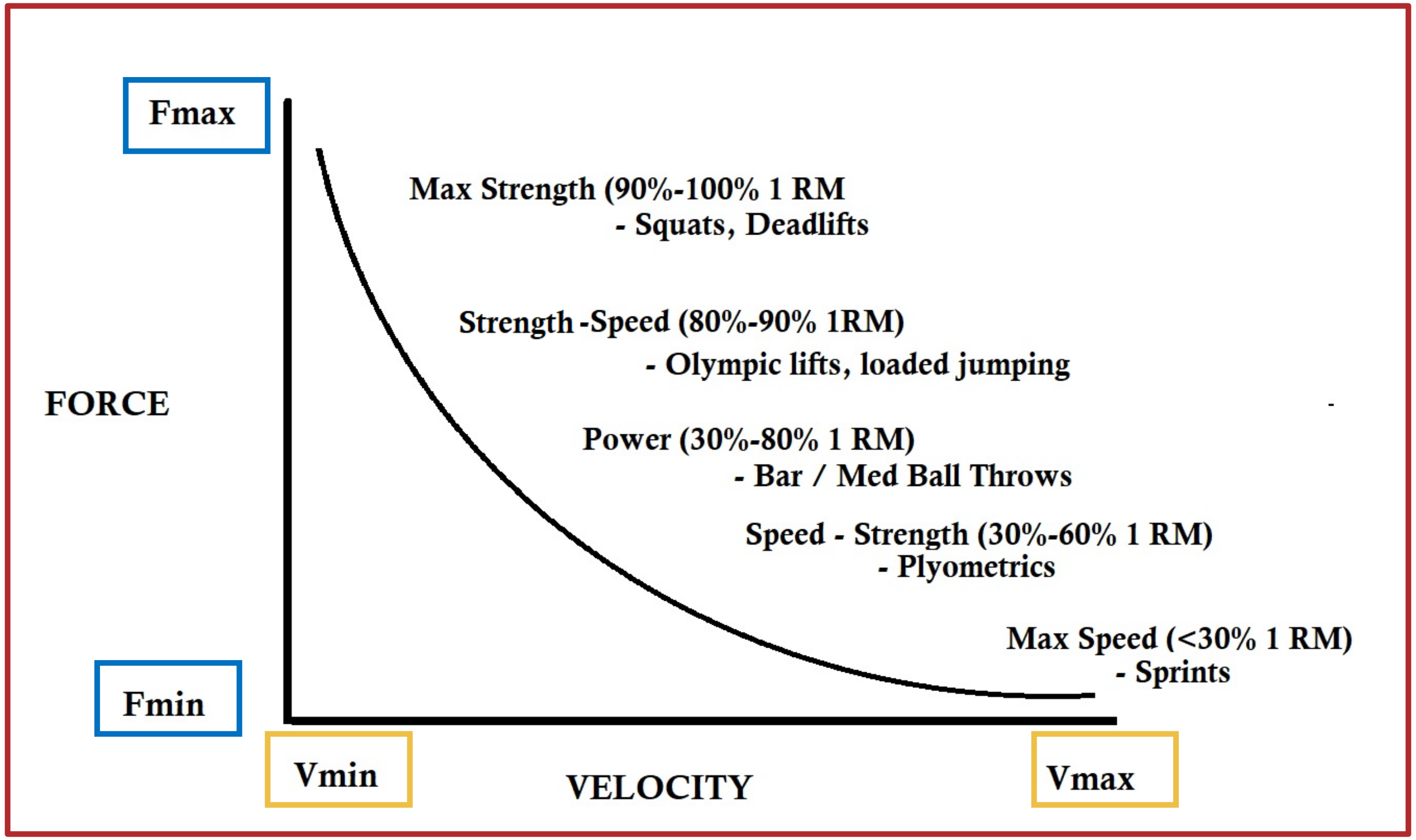
Neumann, D. A. (2013). Kinesiology of the musculoskeletal system-e-book: foundations for rehabilitation. Elsevier Health Sciences. Fig 3-15, pg. 59



Kraemer, W. J., Fleck, S. J., & Deschenes, M. R. (2016). Exercise physiology: integrating theory and application. 2nd Edition. Lippincott Williams & Wilkins.

Understanding the Physiology

- The Force-Velocity Curve



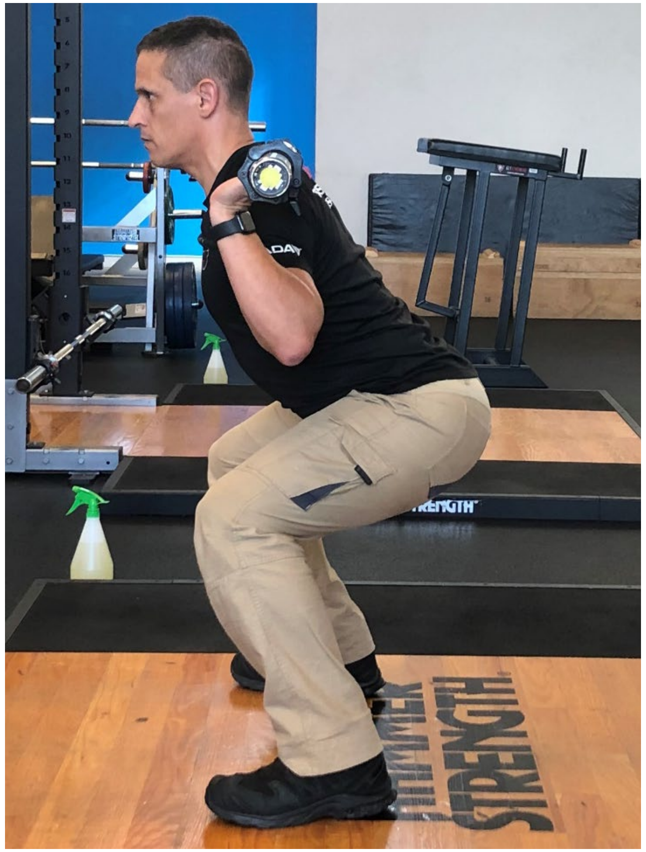
Understanding the Exercise

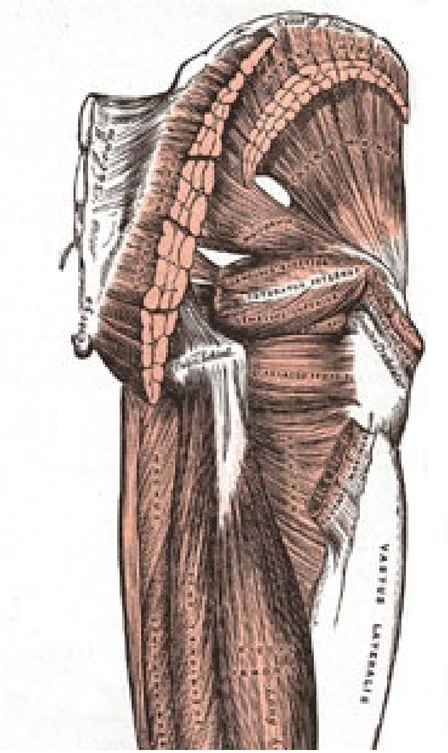
- What squat would you choose to train the Gluteus Maximus?

http://cdn.sheknows.com/articles/2014/03/narrow-squat-to-wide-squat-600w.jpg

Understanding the Exercise

- Right exercise, right technique but are the right muscles active?





http://www.bartleby.com/107/Images/small/image434.jpg

Understanding the Biomechanics

OKC vs CKC

CCK:

- Increased joint compressive forces
- Increased stability
- Decreased shear forces
- Decreased acceleration forces (see Force summation principle)
- Stimulation of proprioceptors
- Better muscle synergistic patterns
- *Proprioception, Joint Position Sense and Kinesthesia are vital to rehab*

Understanding the Biomechanics

OKC vs CKC

CCK:

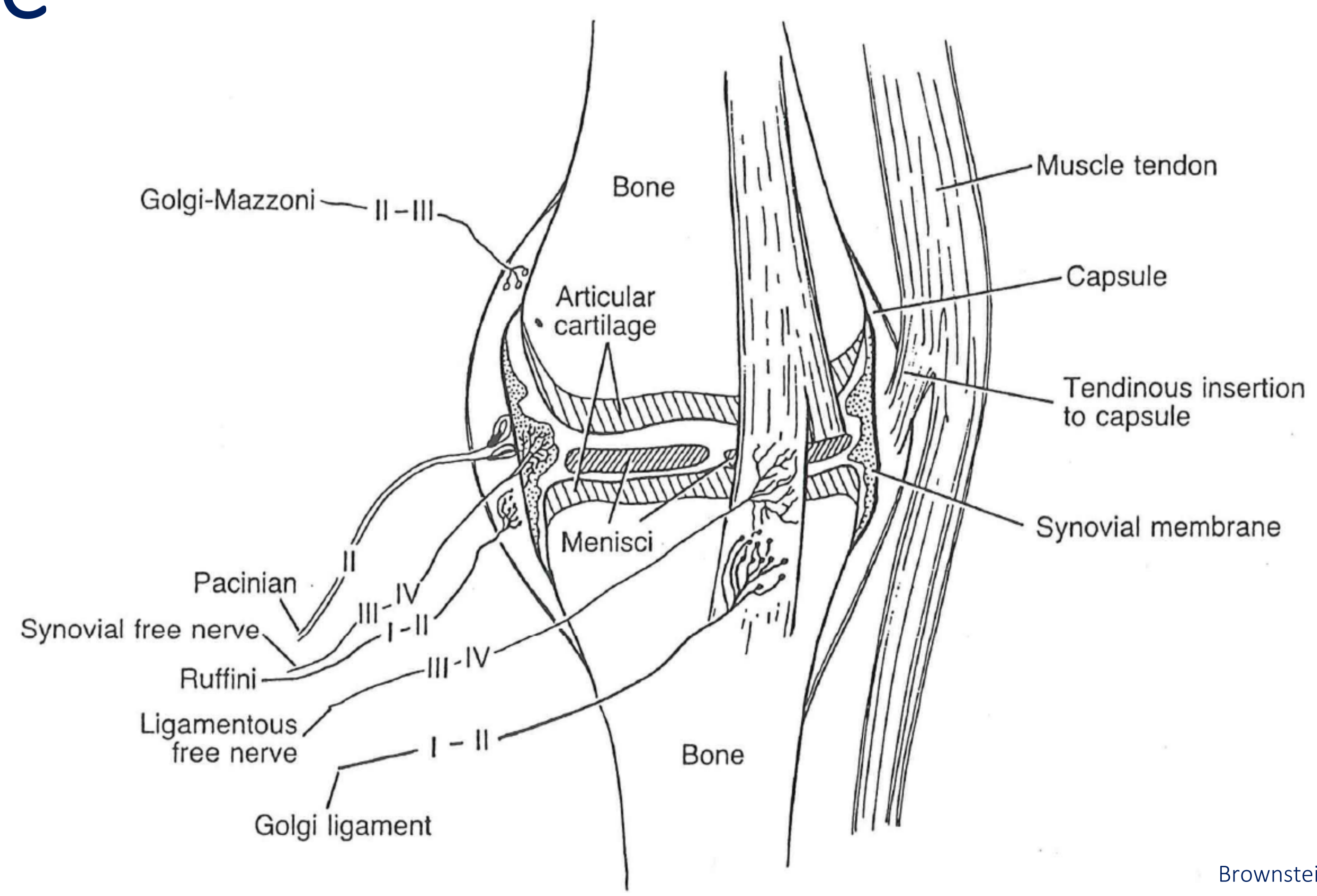
- Pacinian Corpuscle – capsule – vibration/velocity
- Golgi-Mazzoni Corpuscle – joint capsule – compression*

*Insensitive to stretching

- Ruffini Endings – Capsule / Extrinsic Ligs.- stretching
- Golgi-Lig endings – Ext/Int Ligs. – stretching/tension
- Free nerve endings – capsule, ligs. fat pads – mech stress

Understanding the Biomechanics

OKC vs CKC



Brownstein & Bronner (1997), Fig 2-1 p.50

Brownstein & Bronner (1997), Fig 2-1 p.50

Understanding the Biomechanics

OKC vs CKC

OCK:

- Increased acceleration forces
- Increased joint distraction
- Promotion of functional activity?

Understanding the Biomechanics

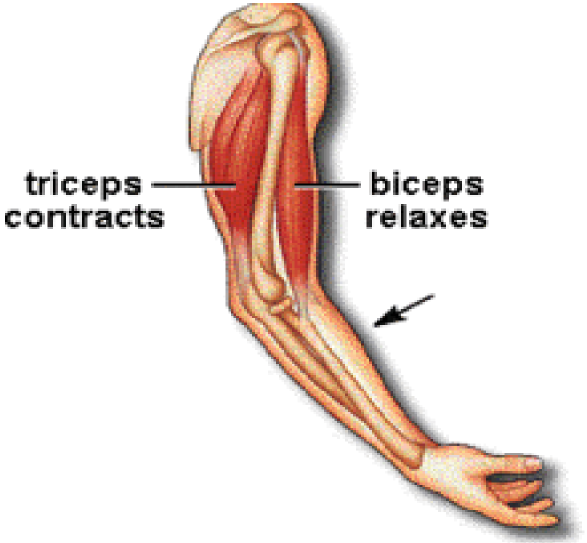
OCK v CKC

- Both OCK and CKC are important
- The question is when to use them as part of conditioning

Understanding the Biomechanics

Reciprocal inhibition

- Describes the process of muscles on one side of a joint relaxing to accommodate contraction on the other side of that joint.



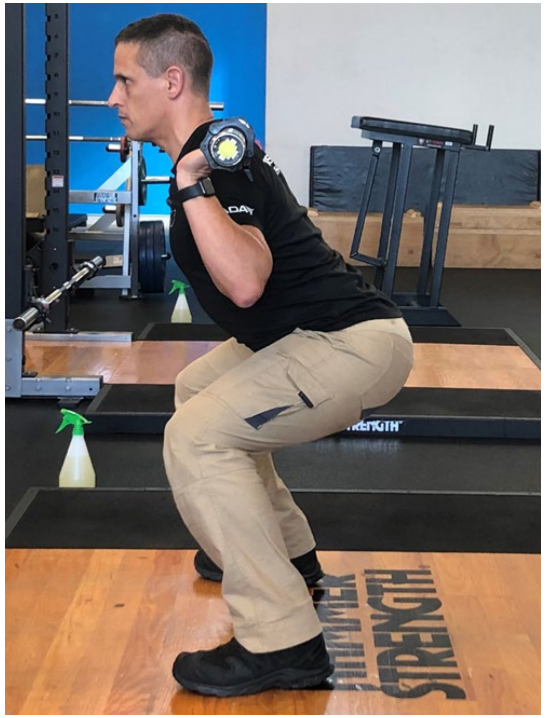
Understanding the Biomechanics

Roles of muscle in movement

- Agonist (leader) – Prime mover
- Antagonist (anti-leader)
- Synergist (works together)
- Fixator

Understanding the Biomechanics

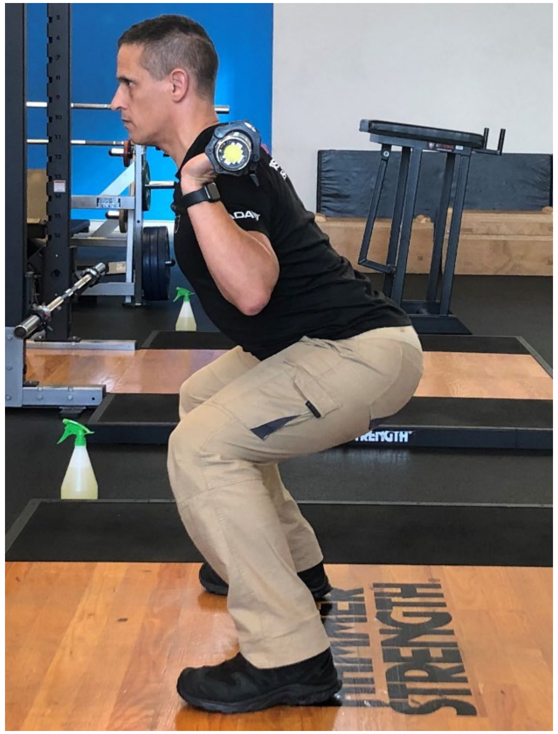
Name the movement at the Hip and Knee during the squat and the muscle agonists?



http://www.numetrex.com/our-pulse/wp-content/uploads/2014/07/squat.jpg

Understanding the Biomechanics

Hip	– Extension	– Glutes & Hamstrings
Knee	– Extension	– Quads

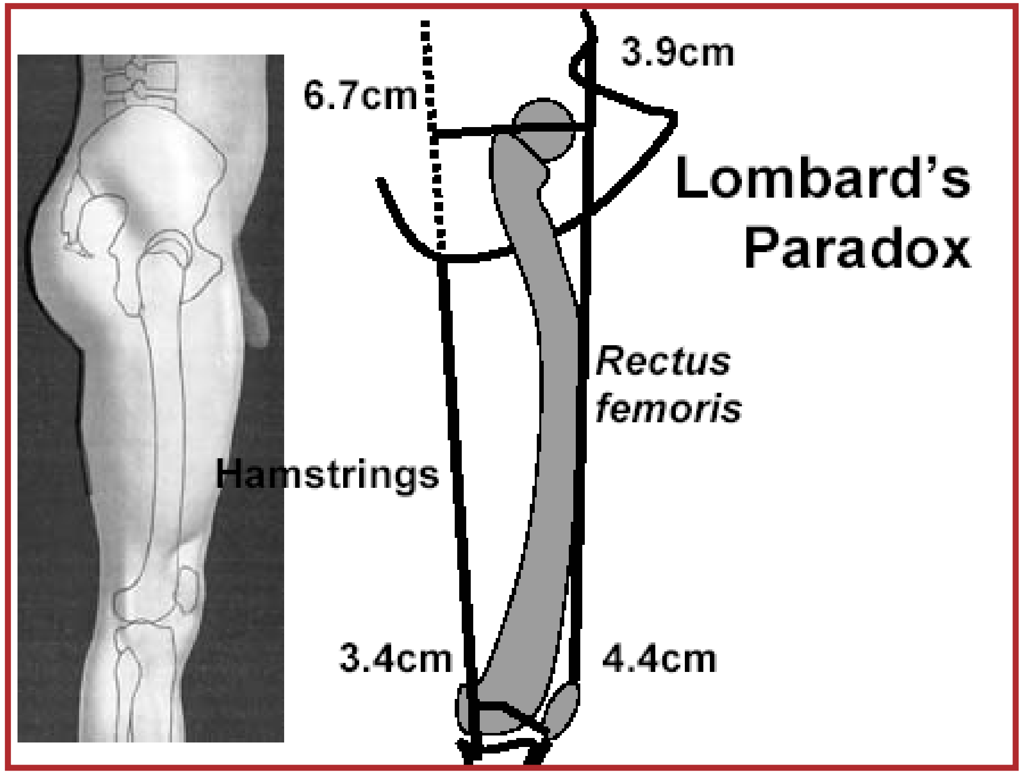


Understanding the Biomechanics

Complex Synergies - Lombard's Paradox

- The longer the lever arm at the joint the more force it develops (e.g. 4.4cm for RF at knee and 3.4cm of Hamstring – Hence knee extension occurs).

- More muscle needed – shape of the Hamstrings (Longitudinal muscle) Quads (Bipennate, Unipennate)



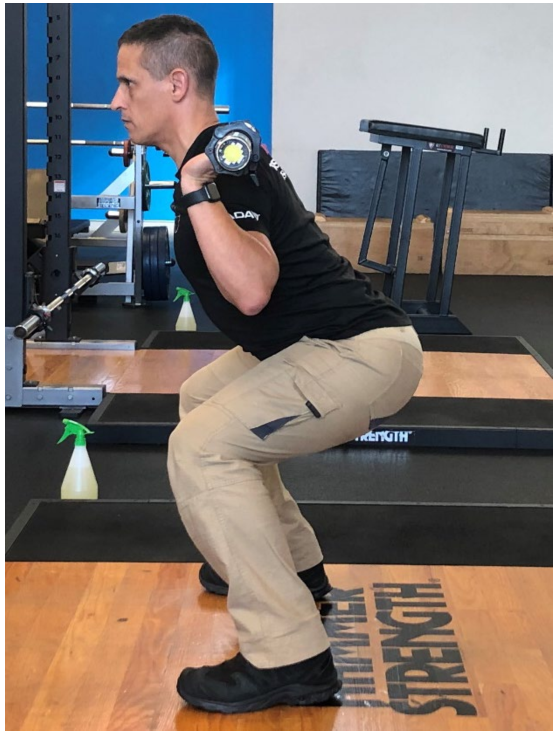
Understanding the Biomechanics

Name the movements of the Hip and Knee joints and the muscle agonists during:

- a squat
- a football kick

Understanding the Biomechanics

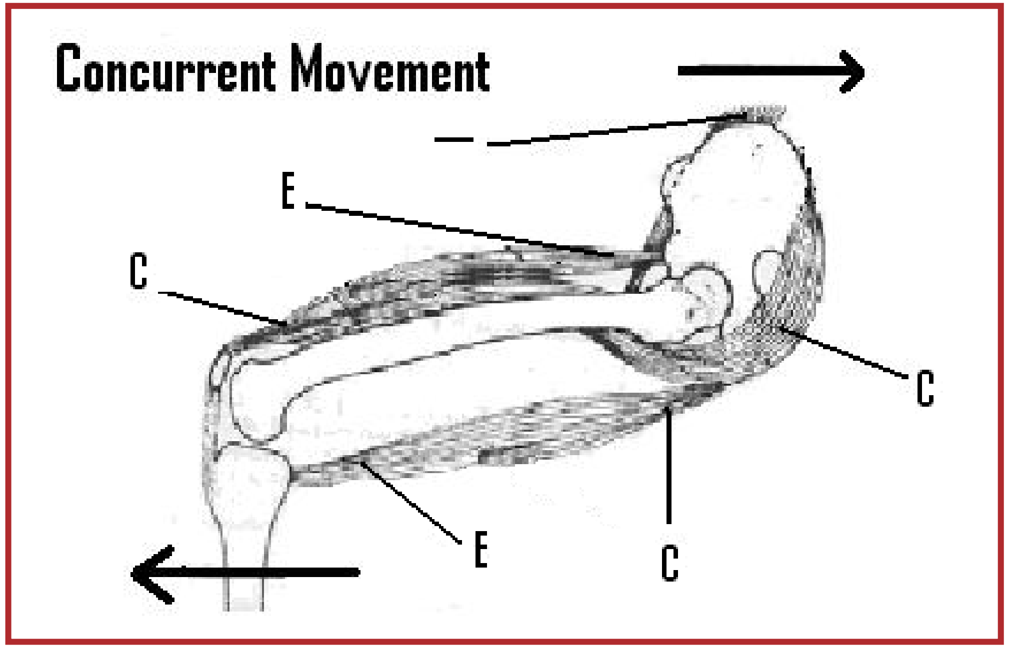
Hip	– Extension	– Glutes & Hamstrings
Knee	– Extension	– Quads

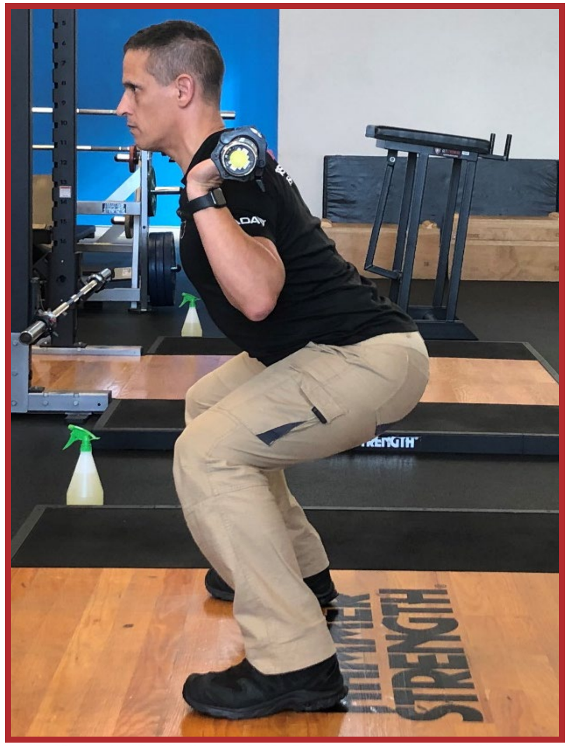


Understanding the Biomechanics

Complex Synergies – Shifts

- In a <u>**concurrent**</u> movement, the biarticular muscle is an **agonist at one** joint and an **antagonist at another** simultaneously





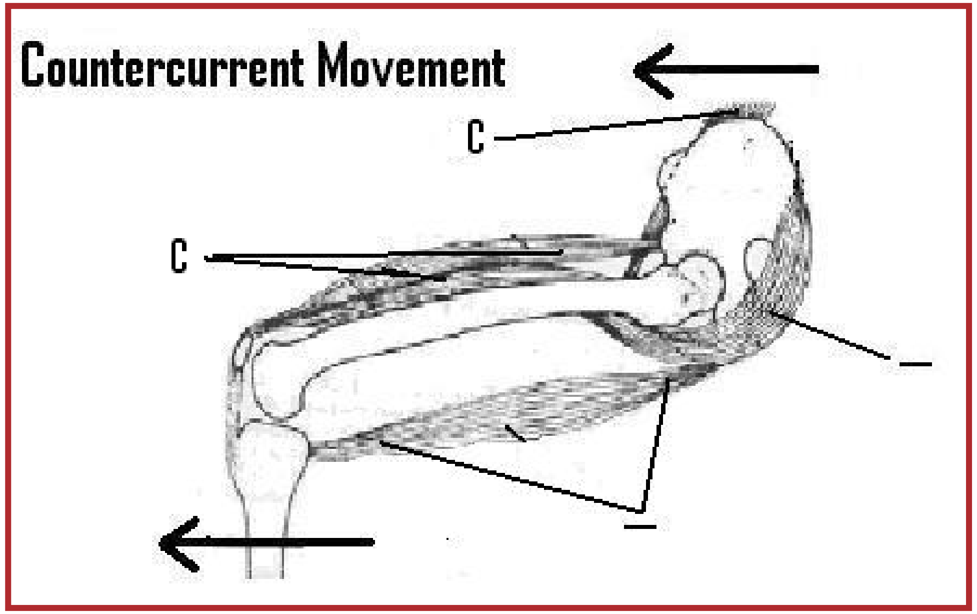
Understanding the Biomechanics

Hip	– Flexion	– Quads & Iliopsoas
Knee	– Extension	– Quads

Understanding the Biomechanics

Complex Synergies – Shifts:

- In a <u>countercurrent</u> movement, the biarticular muscle is an **agonist at both joints** simultaneously.



Understanding the Biomechanics

Complex Synergies – Shifts

- So which one would be better?

Understanding the Biomechanics

Complex Synergies – Shifts

- So which one do we train?

Understanding the Biomechanics

Complex Synergies – Shifts

- So which one do we train?

Understanding the Biomechanics

Synergy

- Optimal coordinated sequence of movement that allows for optimal velocity development
- Each segment begins to move the instant the previous segment begins to slow down

\- +

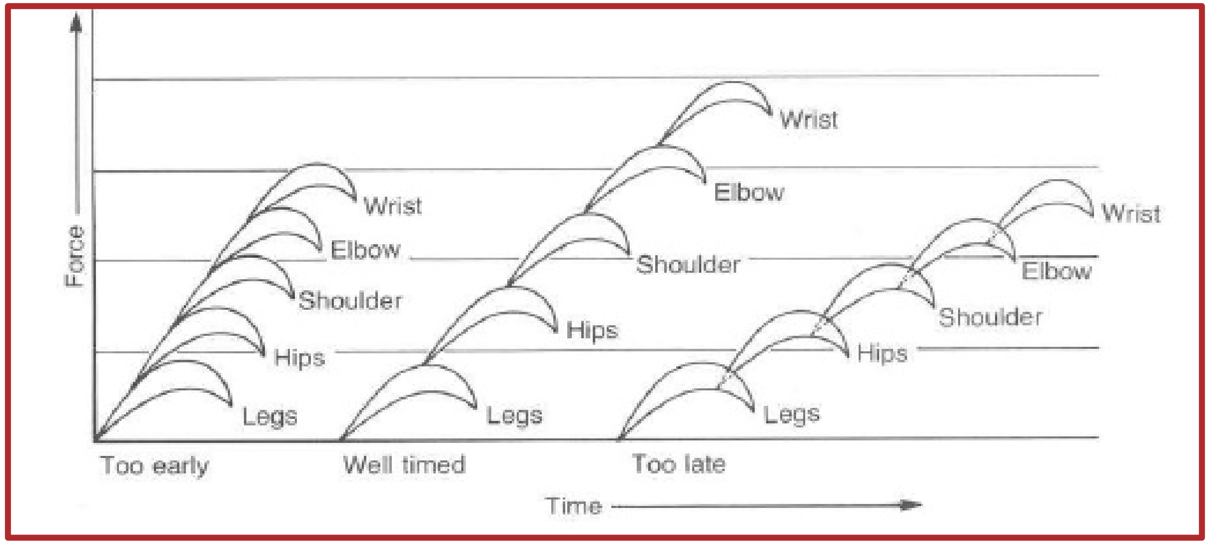
Isolated Compound Kinetic Link

Complex Multi - plane

Understanding the Biomechanics

Segmental Summation of Velocity

- Optimal coordinated sequence of movement that allows for optimal velocity development
- Each segment begins to move the instant the previous segment begins to slow down



Elliott, B.C. Biomechanics in Sport in eds. Pyke, FS. Better Coaching, Australian Sports Commission, Figure 7-13, p.107

Understanding the Biomechanics

Balance Profile

Dynamic

Static

Balance

Counterbalance

Exercise Considerations

Exercise Considerations

MOI:

- Slips, trips, falls
- Muscle stressing

Exercise Considerations

Movement Patterns:

- Concurrent Shift
- Countercurrent Shift

Exercise Considerations

Movement Patterns:

- Concurrent Shift
- Countercurrent Shift

Exercise Considerations

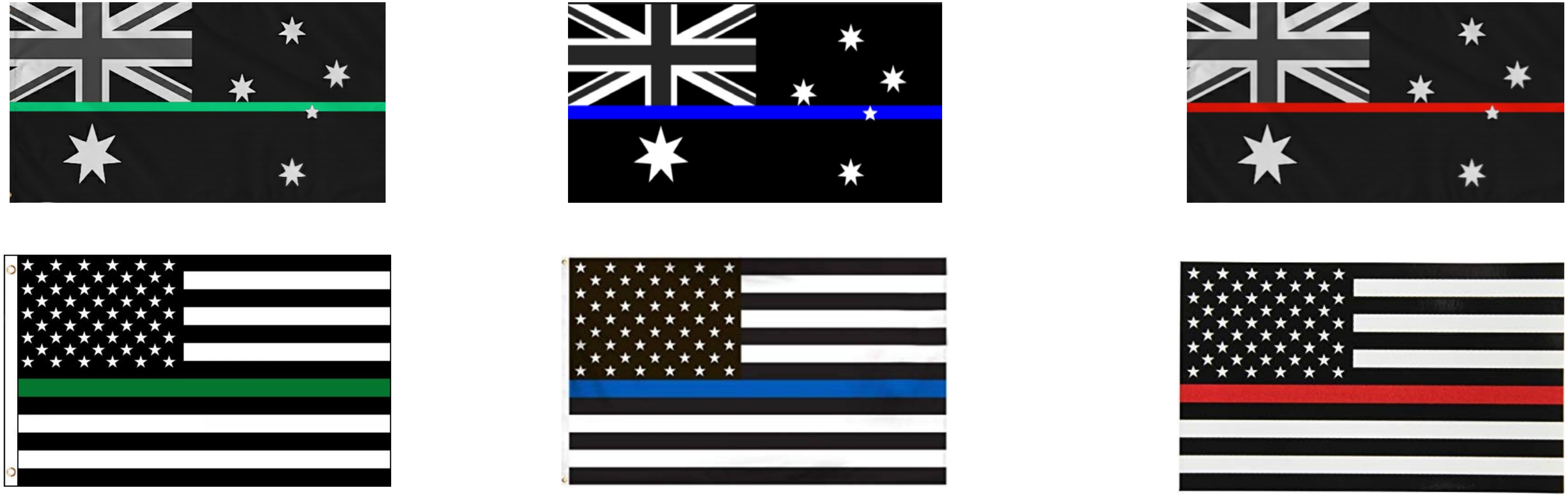
Movement Patterns:

- Segmental Summation of Velocity
- Variability in Movement

Take Home

- Need to consider the anatomical, biomechanical, and physiological influences imparted by lower limb structures when designing programs if you are to use an evidence-based approach to increase neuromuscular resilience for the lower limbs

Thank you



Questions?

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